§12. Observations of Termination Processes of Long Pulse Discharges in LHD

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Long pulse discharges in the Large Helical Device (LHD) have been routinely monitored with about thirty video rate CCD cameras (30fps) and three fast framing cameras (>1,000fps) for observing termination processes of the plasma discharges. In long pulse plasma discharge experiments in the previous (17th) campaign in FY2013, it was found that the plasmas were often terminated by release of large amount of dusts, which consist of deposited carbon-rich mixed material layers, from closed divertor regions. In the last (18th) experimental campaign in FY2014, two different kinds of plasma termination due to dust emission were observed. The first one is plasma termination by dust emission from closed divertor regions, which is the same as that observed in the previous experimental campaign. The second one is plasma termination by dust emission from the surface on armor tiles on helical coil cans.

As a typical example of the first plasma termination process, figure 1 shows sequential images of a long pulse discharge observed from an outer port (9-O) just before the plasma termination. In this discharge, a bright spot appeared in a closed divertor region at a position near the equatorial plane in the inboard side of the torus. After that, the bright spot expanded along magnetic field lines in the plasma periphery in the inboard side. A visible spectrometer for monitoring impurity emission in the plasma showed that increase in the intensity of carbon ion emission (CIII) preceded that of iron ion emission (FeXVI). After the experimental campaign, traces of the exfoliation of carbon-rich mixed material layers including brittle iron layers were found on the surface of a dome structure in the closed divertor region. It indicates that large amounts of dusts consisting of the mixed material layers exfoliated from the dome structure penetrated into the main plasma, leading to radiation collapse to terminate the long pulse discharge.

As a typical example of the second plasma termination process, figure 2 presents a snapshot of a long pulse discharge taken with a tangentially viewing fast framing camera installed in an outer port (6-O) just before the plasma termination. It shows that large amounts of small incandescent dusts released in the plasma. The dusts appear to be from positions around a lower port (5.5-L). The visible spectrometer showed that increase in the intensity of the iron ion emission preceded that of carbon ion emission. After the experimental campaign, a number of arc traces on the surface of armor tiles for protecting a side vacuum wall of a helical coil can were found on the site near the lower port. It strongly suggests that the large amounts of iron grains were sputtered from the surface of the stainless steel armor tiles penetrated into the main plasma, leading to termination of the long pulse discharge.

The above two observations indicate that besides reduction of the deposition of the carbon-rich mixed material layers in the closed divertor regions, control of emission of iron dusts from the surface on the armor tiles by plasma-wall interactions is an essential issue for extending the duration time of the long pulse discharges. In addition to this, understanding on the physical mechanisms of the formation of the arc traces and investigation of the physical processes that initiates the arcs are important issue to realize steady state plasma discharge operation in LHD.

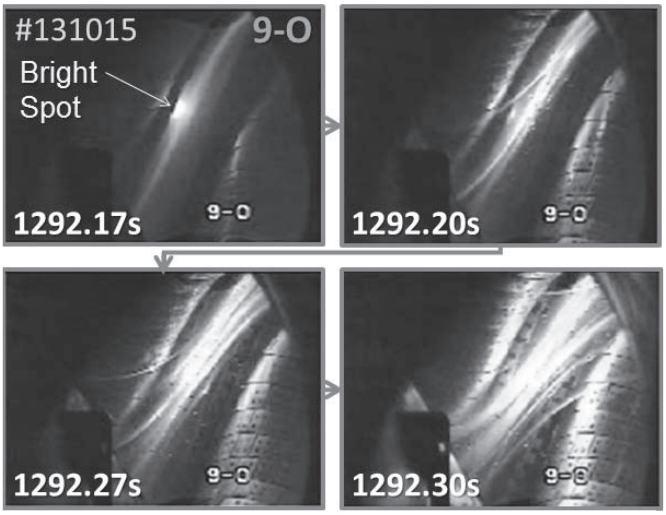

Fig. 1. Sequential images of a long pulse plasma discharge observed from an outer port (9-O), which show dust emission from a position in a closed divertor region near the equatorial plane in the inboard side of the torus.

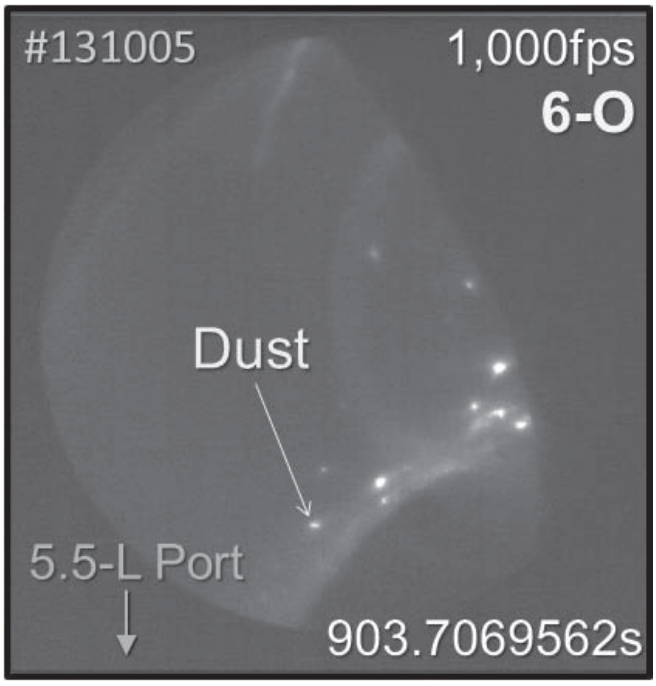

Fig. 2. A snapshot of a long pulse plasma discharge showing a number of incandescent dust release in the plasma, which was taken just before the plasma termination from an outer port (6-O).